fouled air can we breathe? How much filth can we spew into our rivers and lakes? How much bleakness and ugliness can we tolerate?

► Eighth is the *reshaping of government*, the age-old problem of how best to organize ourselves to accomplish our shared purposes. We have indulged ourselves far too long in the luxury of supposing that everything in this country must change and develop except our governmental structure and processes.

Until state and local governments revamp their antiquated procedures and develop the strength to carry the heavy burdens that have been thrust upon them; until Congress faces up to the requirements of reorganization; until the Executive branch carries considerably further its present efforts to streamline its departmental structure and create mutually respecting partnerships with state, local, and nongovernmental agencies; until all these steps are underway we shall continue to be hobbled in the race with change.

► My ninth problem concerns *economic growth*. Since the 1930s we have made impressive gains in stabilizing and managing the economy. Because of what we now know about the sources of economic growth we can envisage the elimination of poverty, the rebuilding of our cities, wise use of our natural resources, and more imaginative use of human skills. To the extent that we sustain a high rate of economic growth, all our other problems will be easier.

► The final item on my agenda is the *relationship of the individual to society*. Everything that we do, all that we achieve, must finally be measured in terms of its effect on the individual. We set out to create a society in which the individual could flourish. But our highly organized society carries its own threats to individuality.

We can avert that threat. We can't escape size and complexity today, but we can design our institutions so that they serve the individual as well as the system. Our goal should be a society designed for people; and if we want it badly enough, we can have it.

One striking feature of our situation today is that we are creating new problems as we go along. Some of the most interesting of the new problems stem from scientific and technical advances. Consider the problems posed by some of the new mind-affecting drugs. Consider the economic, ethical, and social problems posed by the possibility of artificial organs, or weather control, or the control of genetic processes.

OUR capacity to create new problems as rapidly as we solve the old has implications for the kind of society we shall have to design. We shall need a society that is sufficiently honest and open-minded to recognize its problems, sufficiently creative to conceive new solutions, and sufficiently purposeful to put those solutions into effect. It should be, in short, a self-renewing society, ready to improvise solutions to problems it won't recognize until tomorrow. The vitality of our science and technology will have a good deal to do with whether we achieve that kind of society.

John W. Gardner, a psychologist by profession, is U.S. Secretary of Health, Education, and Welfare and generally considered the most influential intellectual in President Johnson's Cabinet.

WHAT LIES BEYOND VIETNAM?

2. Literate Engineering

—*Dept. of Commerce.*

By J. HERBERT HOLLOMON

TODAY you and I can buy a house, but we cannot buy an attractive city; you and I can buy a car but we cannot buy an efficient highway; you and I can pay tuition for a son to go to college but we cannot buy an educational system. The public—in the small or large—buys these public goods: school systems, cities, suburbs, road systems, air pollution control systems, airways systems. Today an increasing share of your and my money is being spent for public goods as contrasted with private goods. This is because we live closer together, have become more interacting and interdependent than we ever were before.

What are the roles of engineering and industry in meeting our needs for public goods?

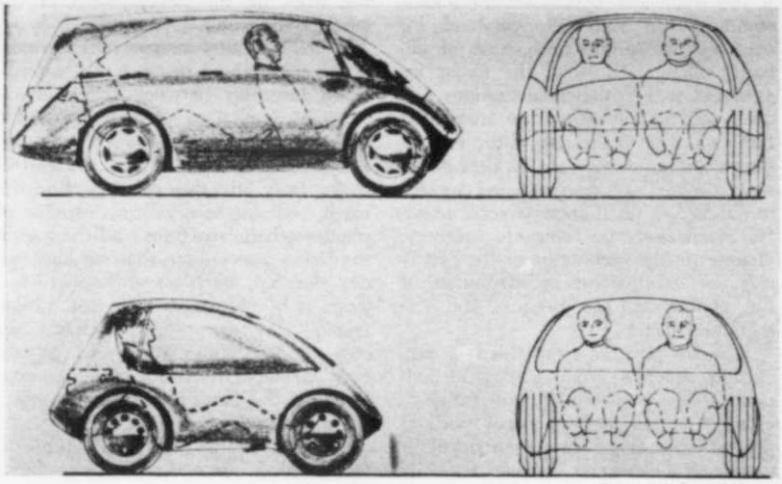
John R. Pierce of Bell Telephone Laboratories recently wrote in *Science* magazine that we are alienating engineering from the productive civilian economy which makes possible both our good life and our expenditures on defense and space. We are doing this inadvertently through the nature and magnitude of the support given to university engineering research by defense and space agencies.

As Dr. Pierce pointed out, the Department of Defense, National Aeronautics and Space Administration, and Atomic Energy Commission are now together responsible for 80 per cent of the support for graduate engineering education in the United States. These and all other government agencies properly tend to support research that advances disciplines of importance to them. Thus our engineering schools are now concentrating on research in such glamorous and highly specialized subjects as aerodynamics, electronics, and solid-state physics, which lie at the very heart of the most sophisticated technology in this country and which do in fact give us the world leadership in the defense establishment and in space. But these are not necessarily the disciplines that are related to the civil, economic, or social goals of the United States or the rest of the world. The result is that most of our graduate education in engineering schools is graduate "scientific" engineering education, and the difference between the education of people to do engineering and to do engineering science is almost the difference between day and night.

This situation is self-perpetuating. Almost all the engineering professors now coming into teaching have doctorates based on this kind of research experience, and very few have had industrial experience. The teachers teach the students who teach the students, and this assures us in endless cycle a supply of engineering scientists oriented to highly specialized and sophisticated problems. It is a cycle which in some part at least must be broken.

It is clear that the national agencies have a responsibility to ensure that the sophisticated disciplines of engineering and science pertinent to their business are well supported. I am simply proposing that support is also needed for the application of sophisticated techniques to industrial practice, the application of imaginative design to construction, the use of modern technology to control pollution, the application of imaginative engineering so that we are able to operate our motor vehicles without killing as many people each year as we kill in most large world wars.

The use of technology is almost never limited by technology itself. It is limited



—*Courtesy of General Motors.*

Sketches above are artist's conception of limited-emission vehicles now being designed for diminution of air pollution and easing of urban traffic jams. In experiment planned for Philadelphia by University of Pennsylvania under subsidy from U.S. Department of Housing and Urban Development, small light-weight cars would operate by coin or punched card as pay telephones now do; parking lots at railroad stations would hold vehicles for commuters, who would drive into town, debark, and leave the empties for recovery by a community pickup service.

by social, political, and economic forces—the organizational structure of a company, the attitudes of people. So I urge that the engineer, if he is to be effective in a modern world, has to be literate. He must have some concept of the society in which he operates—its economics, its politics, its art, its esthetics, its laws. The society of engineers must encompass people who are deeply wedded to the value systems of our society—men who concern themselves with whether or not engineering is worth doing at all. It is a travesty, in my view, that engineers are responsible for the design of vehicles in which so many people are killed or maimed. It is a travesty that engineers are responsible for the design of industrial plants that pollute our atmosphere and our streams. Engineers must feel a sense of moral values through which they weigh the consequences for evil as well as the consequences for good of their work and make some judgments between them.

J. Herbert Hollomon was the first assistant secretary for science and technology in any Cabinet department in Washington. Now deputy secretary of the Department of Commerce, he will soon become president of the University of Oklahoma.

WHAT LIES BEYOND VIETNAM?

3. Planetary Engineering

—*U. of Miami.*

By S. F. SINGER

DURING our lifetimes, and especially in the past few years, we have witnessed a sudden extension in the scale of exploration of our physical environment away from the surface of the earth: down into the oceans, and into the earth's crust towards the mantle boundary, as well as upward into the atmosphere, and even beyond the atmosphere toward the moon and earth's neighbor planets. Coupled with this explosion in our capabilities to *explore* has come a more modest extension of our *understanding* of the natural environment, especially of the relationships between different parts of the physical environment. In addition, important ecological relationships to the biosphere are gradually being unraveled.

The next step must surely be modification and management of the environment. Actually, this phase has been underway for quite some time. In his fight with the natural environment, man for thousands of years has been forced into the position of finding or constructing protective shelters, principally against the weather. Through agriculture and irrigation, man entered the stage of transforming to some extent the external physical environment. This has been a haphazard process, largely unplanned, and conducted on a small enough scale so that its consequences have not been felt on a world-wide basis. But as the industrial revolution has amplified the energy management capability of man, major projects of environmental modification have been carried out: e.g., the digging of the Panama Canal, the filling of the Zuyder Zee in Holland, and, quite recently, the Snowy Mountain Project in Australia which resulted in reversing the course of several rivers for purposes of irrigation and generation of electric power.

In addition to planned projects, some unplanned changes have also taken place, including the severe water and air pollution produced by all kinds of human activities. Some changes were not only unplanned but also unnoticed until recently. For example, the burning of large amounts of coal and oil during the past 100 years has led to a large increase in the concentration of carbon dioxide in the atmosphere with consequences for the earth's climate that are not yet known with any certainty.

Powerful technical means are now at hand that can revolutionize the future of environmental control:

► Observational techniques based on earth satellites, which can give us detailed information on environmental changes over the whole globe on a nearly simultaneous and continuous basis. We can then trace changes in climate, and relate these to the behavior of the oceans, to the ice and snow cover and other properties of the surface, and to space radiation.

► Data-processing methods based on electronic computers, which can convert this mass of data into meaningful quantities that the brain can grasp.

► Cheap and controlled energy based on nuclear fission reactors and even nuclear explosives. Controlled hydrogen fusion is still eluding us; but eventually, the availability of energy from hydrogen atoms will change the energy dimension again by orders of magnitude.

► Development of systems analysis concepts and methods, and of people who are trained to deal with incredibly complicated technological problems.

With these tools at our command, we can think of tackling not only the im-